Final Project Report (to be submitted by 20th September 2018)

Instructions:

- Document length: maximum 10 pages, excluding this cover page and the last page on project tags.
- We welcome the submission of Annexes (i.e. bachelor or master thesis, references, species lists, maps, drawings, pictures) to further HeidelbergCement's understanding and future use of your findings, however they will not be reviewed by the Jury, and we kindly ask for these to be sent separately to the National Coordinators.
- Please use the attached template for species data collected during the project and submit with the project report.
- Word/PDF Final Report files must be less than 10 MB.
- If you choose to submit your final report in your local language, you are required to also upload your final report in English if you wish to take part in the international competition.
- To be validated, your file must be uploaded to the Quarry Life Award website before **20th September** 2018 (midnight, Central European Time). To do so, please log in, click on 'My account'/ 'My Final report'.
- In case of questions, please liaise with your national coordinator.
- You should not publish additional private information in your final report (e.g.: address, day of birth, email-address, phone number), just complete the categories we ask for below under "Contestant profile".

The final reports should comprise the following elements:

For research stream projects:

- Abstract (0,5 page)
- Introduction :
    - For projects that are building upon a previous project, write a summary of actions that were already completed in the previous project.
    - Project objectives
- Methods: a detailed description of the methods used during the project is required.
- Results: the results of the project should be outlined and distinguished from the discussion.
- Discussion:
    - Results should be analysed and discussed with reference to region/country taking into account other publications.
    - Outline the added value of the project for science and for the quarry / company.
    - Recommendations and guidance for future project implementation and development on site is requested. Where possible, please mention the ideal timing and estimated costs of implementation.
- Final conclusions: a short summary of results and discussion.

For community stream projects:

- Abstract (0,5 page)

- Introduction
    - For projects that are building upon a previous project, write a summary of actions that were already completed in the previous project.
    - Project objectives
    - A short description of the site and the team members and the targeted audience of the project.
- Actions and activities: a detailed description of planned or implemented actions and outreach activities done to elaborate the project, list of stakeholders involved.
- Discussion:
    - Project teams should discuss the pros and contra and illustrate experiences.
    - Outline the added value of the project for biodiversity, the society and the quarry / company.
- Deliverables: practical implementation and development recommendations of the project are required. Where possible, please mention the ideal timing and estimated costs of implementation.
- Final conclusions: a short summary of the project findings and discussion.

1. Contestant profile

▪ Contestant name:	Maria Reyes Martin Toral
▪ Contestant occupation:	Student
▪ University / Organisation	Universidad Complutense
▪ Number of people in your team:	4

2. Project overview

Title:	Enhancement of pollination networks in restored quarries
Contest: (Research/Community)	Research
Quarry name:	Valdilecha

Abstract (max 0.5 page)

Text in Arial 10

The pollination is one of the main ecosystem services, due to its importance in the viability of many species. However, we are facing a "pollinator crisis" where an accelerated mortality of these has already been reported (UNEP).

This project aims to study the connectivity of these animals between the restored plots of quarries and the surrounding areas, with the aim of enhancing their population, and to ensure the ecosystem process within the farm, so that the maximum level of restoration will be succeeded with the minimum intervention possible.

Moreover, the target of this project is to achieve this by building artificial islands of vegetation, and the construction of shelters, so that it creates stable areas where the Apoideos can develop. If effective, it would be a pragmatic, economical and feasible possibility of increasing the ecosystem services in degraded areas. Although FAO recognizes the effectiveness of habitat creation practices to increase bee populations, these actions have never been verified in extractive environments at our latitudes, and hence the scientific and applied importance of the project.

Final report (max 9 pages)

Text in Arial 10

Pollination is one of the most important ecosystem services, not only because of its involvement in the maintenance of the local plant biodiversity (87% of flowering plants need insects to ensure their reproduction (Ollerton, 2011), but also, because of its value in agricultural production, where more than 1500 crops depend on this (Klein, 2007). In temperate regions, most of these services are made by honey bees, solitary bees and bumblebees, all included in the superfamily Apoidea (Klein, 2007). This gives it high ecological value, and when it is quantified economically (for example if that job had to be done by humans) is around 361 billion dollars globally (Lautenbach, 2012).

Despite the fact that we are in a "pollinator crisis", whose main fault are the air pollution, the abuse of pesticides (neonicotenoids) and the environmental degradation, which causes a decrease in the plant populations. Based on the findings mentioned above, it is necessary to apply ecological restoration techniques to ensure the provision of the ecosystem services. In order to have a good pollination restoration design, we have to take into consideration the plant-pollinator network characteristics, the ecological conditions of pollinators and the landscape structure in relation to their movement (Menz et al, 2011).
As we know that pollinators are grouped according to hot spots the pollination capacity in the future will depend on the pollinators´ ability to migrate through these places by highly fragmented habitat matrices (Dixon 2009), so it is very important to assess how quarry construction affects them. The creation of vegetation islands would be a possibility to deal with this, by improving degraded situation matrices in order to facilitate the process of colonization.
For this, we have to take into consideration that there are 3 types of useful plants in the process of the restoration of the pollination. The "framework plants" which support the pollinator communities, providing a lot of nectar and pollen resources. The "bridge plants" which provide resources in no time, and finally the "magnet plants" that have attractive shapes, which attract insects (Winfree 2010).In addition to this, the author also mentioned that artificial nesting sites could also facilitate the colonization of these insects.

Objetives

With this project we intend to emphasize on the importance of the construction of these modules in the maintenance of the pollination service during the period of exploitation of the quarry. We subdivide it into 3 subgoals:
1. Evaluate if the existence of vegetation plots or floral diversity will favor the presence of pollinators studies. In order to see if it favors the process or not, we will observe our modules and the ones outside and compare where we have a greater number of pollinators.
2. Check if the artificial shelters (popularly known as "insect hotels") favor the presence and establishment of pollinators. To do this, two of the four revegeted modules have an installation of ta shelter.
3. Study if these plots will allow the connectivity of the populations with the environment, trying to reduce the fragmentation of our studied habitat, evaluating the diversity-stability relationship of the floral production. This will be carried out with plantations in different points of the quarry.

Methodology

a. Performance area

Valdilecha quarry is located in the southeast of the Community of Madrid (40 ° 17'44 "N 3 ° 18'14" W). This space has a temperate Mediterranean climate. Predominant vegetation are herbaceous, with a variety of bushes and trees scattered around, and a clear anthropic influence (cultivated and abandoned soils, degraded spaces, like the quarry for example). The species which are found in the study area were characterized as part of the project, and they are detailed as *Annex 1*, indicating the specific dominance and type of pollination that they have adopted. In general, these plant communities are included in the optimum climatic vegetation of the Castilian basophilic

Mesomediterranean Aragonese series (Bupleuro rigidi - Querceto rotundifoliae sigmetum) of Rivas-Martínez (1987) and they are recognized as priority habitat in the Management of Habitats (1520, "Iberian Gipsícola Vegetation")

b. Experimental method

In this project we created four vegetation modules on the margins of the quarry, by connecting apoideos population that are surrounding quarry exploitation, and facilitate them to enter into the restored areas of the quarry. Modules measurements are 5 x 3 meters. In each vegetation module, planting frames of randomly distributed species were made.
Apart from that, the team chose four more zones into the quarry and eight zones outside the quarry with natural vegetation, near the quarry, but without entering croplands or quarry areas, which are abundant in these places. The minimum distance among the zones is 100 meters.

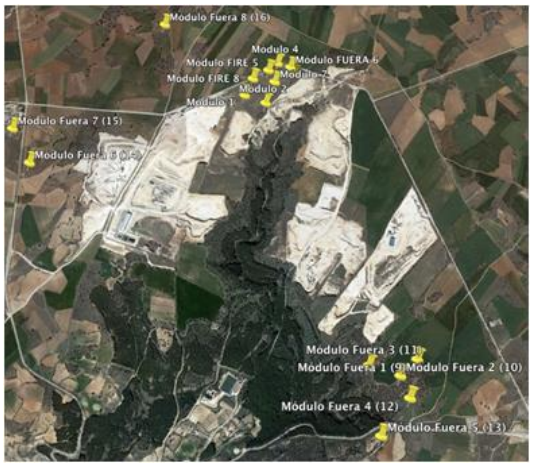

Image 1. Location of the modules.

In order to choose the proper species, the team took into account various factors like native species from Mediterranean areas, their flowering time, soil characteristics in this area, and appropriate species with adequate growth in this restoration area. Furthermore, all the plants we have selected are entomophilous, and in spite of *Asphodelus albus* and *Thymus vulgare* were found in the surrounding vegetation area, all the species are adapted and are part of Madrid southest floral border.
We destacated *Vella pseudocytisus*, a branched and bristly shrub, that reaches an average height of 1.5 meters. It has numerous pedicelled and clustered flowers, with entomophilous pollination by Lepidoptera, Hymenoptera, Diptera and Coleoptera (Granados, 2012). The selection is classified as "High interest" in Madrid, and listed as "Endangered" (EN) , by IUCN and by Atlas and Red Book of the Endangered Vascular Flora of Spain. *Vella pseudocytisus* is threatened mainly by reforestation and agricultural crops, due to the decrease of the availability of the habitat. They have affected all taxon and has been proven his incidence (Benito et al., 2004).

All the species used, during this project, are indicated in *Annex 2*, and the reason for their selection, too.

Specie	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Asphodelus albus		X	X	X								
Colutea arborescens			X	X	X	X						
Ephedra fragilis				X	X							
Genista scorpius				X	X							
Jasminum fruticans				X	X	X	X	X				
Lavandula latifolia		X	X	X	X	X	X	X	X	X	X	

Rosmarinus officinalis		X	X	X	X	X	X	X	X	X	X	
Salvia pratensis					X	X						
Sedum sediforme						X	X	X				
Thymus vulgare			X	X	X	X						
Vella pseudocytisus		X	X	X	X							

Table 1. Flowering periods of the selected species

c. Placement of the shelters

Furthermore, shelters were placed in two of the four modules, one of them in module 2 (orientation N), while the other one in module 4 (orientation SE), both on two oaks, with similar height (1.80m). These shelters were made of wood, and their dimensions were 18 x 10 x 20 cm.

Image 2. Shelter

d. Connectivity evaluation

To check connectivity between the zones, we painted bees with ultraviolet powders TP-43 Orange and TP-48 Magenta (RADIANT COLOR NV), at noon, when bees have better activity. When sunlight falls and darkens with ultraviolet light, to see if there is connectivity modules and attached to them area.

e. Measurement, observation and counting

Measures were taken one day a week, at similar hours per day but randomizing the order of the modules to prevent influence about time in the final result. The possible presence of bees was maintained for 20 minutes in each module.
Each day of sampling, the total number of flowers in each module was estimated, in order to use this data as a covariate of the presence of bees. To do this, we counted on the number of flowers of each specie, and then we multiply it by the number of copies of each bee that was in the module. It was not discriminated by type of flower or size of the flower.

RESULTS

- The effects of the creation of vegetation modules in the presence of apoideos.

The following table shows the variation over time of the sightings of apoideos in the plots (expressed in logarithm). The blue line (outside) shows averages higher than those that have been found within the quarry, which is a detriment to these animals. However, the orange line (planted modules) is in almost all the samples superior to gray (inside the quarry, with spontaneous vegetation), with which we accept that this action improves the habitat of the bees and enhances their presence, facilitating the provision of the ecosystem service. In addition, in the planted modules, in half of occasions a greater or equal number of insects than outside the quarry has been observed.

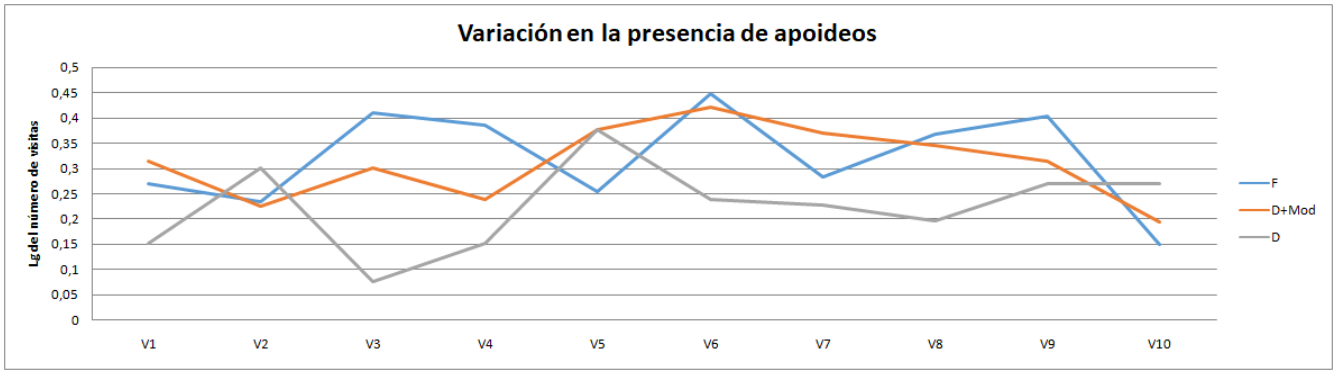

Image 3: Temporal variation in the presence of apoideos.

In Table 2 we can see how there is significant evidence solely in visit 3. Since there is a fairly low presence of apoideos, both in the quarry and in the surrounding areas, it is difficult to obtain significant results.

	V1		V2		V3		V4		V5		V6		V7		V8		V9		V10	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Factor Dentro/ fuera	0,938	-	0,303	-	4,404	*	1,216	-	0,260	-	1,862	-	0,670	-	0,974	-	0,687	-	0,691	-

Table 2. Results of the unifactorial ANOVA. The differences inside / outside in each of the visits are represented. The significant differences (p <0.05) are marked with (*), the rest being non-significant

- The effect of the artificial shelters in the presence of apoideos.

The importance of the shelters in the presence of apoideos in the plots was evaluated through a repeated measures ANOVA. The interaction of refugee * time is not significant (p = 0.669), which indicates that there are no differences in the presence of pollinators according to whether this method is used or not.

- Effect of the modules on spatial connectivity.

Due to the inherent difficulty in the process of this experiment, unfortunately, we did not obtain results, since no bee returns were observed at the points of origin or the rest of the modules.

- Specific survival in the construction of modules.

When observing the survival and mortality of the plants after the summer, on September 7, the following data was obtained shown in Annex 3, and summarized in the following graph.

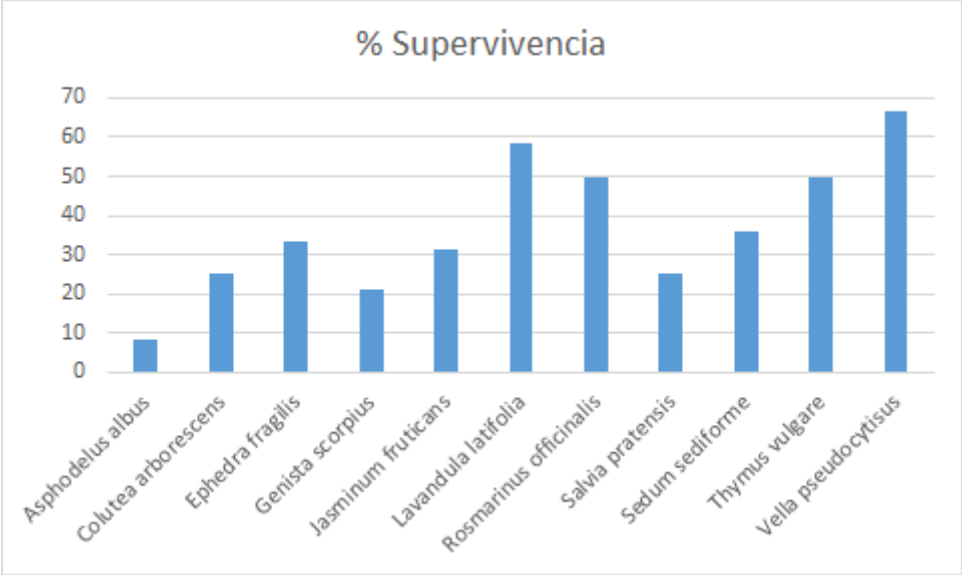

Image 4: Percentage of survival of the species used.

It can be seen that the greatest amount of survival has been noticed in module 1, an acceptable amount in modules 2 and 4, and a very low amount in module 3. This may be due to the fact that the soil in module 3 was not suitable for the plantation, since it had conditions that prevented to realize an adequate depth of the holes to place the plants. Evaluating these conditions will be essential to generate lasting actions.

Discussion

Taking into account these results we accept that the planting of modules has a positive effect for the Apoideos, improving their presence in the surrounding areas of the quarry. This performance had a certain logic, based on the ideas discussed above, however, we were surprised by the rapid effect it had. The team consider that this had a double motive: on the one hand, that in summer the quarry was devoid of active vegetation due to the drought, while the modules went ahead, which facilitated their nutritional use. On the other hand, we have verified the presence of species of excavating bees to which it would be much easier to nest in an unpacked and aerated land, which in the quarry could only be that existing in plantations.
In certain occasions, a greater or equal number of insects is observed in the modules than outside the quarry. The possibility must be considered that even a degraded, but well-managed space, can promote the local biodiversity of these animals, improving even the surrounding environment.

Although bees need shelter for their development (Winfree, 2010) there are no differences in our experiment for the presence of these between installing artificial shelters or not. This is due to various factors, from the little use that can be given if most species detected nest in the soil, until they also favor predatory wasps (Altieri 1994) although there is a literature that indicates their value (Stephen, 1961). Therefore it will be necessary to evaluate the species that make up the local entomofauna, to make strategies adapted to it. In the study area we do not recommend this method for the promotion of wild bees, being able to focus our resources on other actions.
The absence of comparable data in the connectivity experiment does not allow us, unfortunately, valid conclusions to be drawn.

Low values in *Asphodelus albus* is because it is an annual plant, thus we found that only two were still in bloom in Module 4. Do not confuse this with their survival during the rest of the process. We discourage the use of *Genista scorpius* and *Salvia pratensis* for the values obtained, although we accept that all would be higher with a maintenance risk.
The most successful survival species were *Lavandula latifolia* and *Vella pseudocytisus*. The first is that it is a species that has its flowering season almost throughout the year, both species have an acceptable establishment and tend to have a high planting density.

In the case of *Sedum sediforme* survival rate it was good in Modules 2, 3 and 4. However, none of them survived in Module 1, despite being a species that has a high summer survival and our plantation took place in April, but it could be more possible but the plantation did not take root well.

The knowledge generated in this work has a double value. At a scientific level, it seeks to better understood, and specifically in the Mediterranean climate, how insects can adapt to spaces affected by extractive works, deepening in the improvement of their habitat to increase their population, and ensure the connectivity and the provision of pollination in the territorial matrix. From this emanates the second objective of the initiative, which is the transfer of this knowledge to the society. In this case to one of the leading companies in the sector, for its implementation. In this, it is necessary to ensure that the actions carried out generate positive results in order to direct the resources in an adequate and efficient manner. In this way, the company can influence restoration plans that focus on pollination, with the minimum cost and aware of which actions are more important and significant, positioning themselves in a strategic place in this field.

The experience in the implementation of this work leads us to the following recommendations:

- Mortality values of the species planted in the modules should be taken into account in order to obtain the smallest possible amounts. We attach a table with our results in this regard (annex 3).
- The ideal temporal distribution would imply a longer sampling period, since the one that has been proposed on this occasion does not allow ensured conclusions, since several months do not coincide with the period of greatest activity of the insects, and the effects are not seen of all plants, because of its small size.
- The cost of implementation we consider that it is sufficient. One of the main forces of the project is the low cost, which allows its easy implementation on farms.
- The study of connectivity using UV powders is very complex in these environments, thus it would be necessary to make a very specific design or choose another technique.

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ANNEXS

ANNEX 1. Vegetation of the zone indicating the specific dominance and the type of pollination that they adopt.

Specie	Location	Dominant or not	Pollination
Anacyclus clavatus	Outside of the quarry	Not dominant	Entomophil
Andryala integrifolia	Inside the quarry	Dominant	Entomophil
Asphodelus sp.	Outside of the quarry	Dominant	Entomophil
Asteriscus aquaticus	Inside and outside of the quarry	Not dominant	Entomophil
Biscutella auriculata	Outside of the quarry	Not dominant	Entomophil
Brassica rapa	Outside of the quarry	Dominant	Entomophil
Bromus sp.	Inside and outside of the quarry	Not dominant	Anemophilous
Carduus sp	Inside and outside of the quarry	Not dominant	Entomophil
Cistus clusii	Inside and outside of the quarry	Not dominant	Entomophil
Convolvulus arvensis	Inside the quarry	Not dominant	Entomophil
Crepis vesicaria	Inside and outside of the quarry	Not dominant	Entomophil
Digitaris sanguinalis	Outside of the quarry	Not dominant	Anemophilous
Echium plantagineum	Inside the quarry	Dominant	Entomophil

Echium vulgare	Inside the quarry	Not dominant	Entomophil
Eryngium campestre	Inside and outside of the quarry	Not dominant	Entomophil
Euphorbia serrata	Inside and outside of the quarry	Not dominant	Entomophil
Euphorbia terracina	Inside the quarry	Not dominant	Entomophil
Helianthemum violaceum	Inside the quarry	Not dominant	Entomophil
Hordeum murinum	Inside and outside of the quarry	Dominant	Anemophilous
Hypericum perforatum	Outside of the quarry	Not dominant	Entomophil
Papaver rhoeas	Inside the quarry	Dominant	Entomophil
Papaver somniferum	Inside the quarry	Not dominant	Entomophil
Parentucellia viscosa	Inside and outside of the quarry	Not dominant	Entomophil
Quercus ilex	Outside of the quarry	Dominant	Anemophilous
Silene colorata	Inside and outside of the quarry	Not dominant	Entomophil
Stipa tenacissima	Outside of the quarry	Dominant	Anemophilous
Taraxacum officinale	Inside the quarry	Dominant	Entomophil
Thapsia villosa	Inside and outside of the quarry	Dominant	Entomophil

Thymus vulgaris	Outside of the quarry	Dominant	Entomophil
Trifolium campestre	Inside the quarry	Not dominant	Entomophil

ANEXO 2: Used species

Specie	Selection criteria
Asphodelus albus	• Magnet plant (big flower) • Framework plant (large amounts of nectar)
Colutea arborescens	• Fast growth • Increase fertility
Ephedra fragilis	• Empower a species in regression
Genista scorpius	• Magnet plant (color of the flowers)
Jasminum fruticans	• Framework plant
Lavandula latifolia	• Bridge plant (Provides recourse in unfavorable times)
Rosmarinus officinalis	• Bridge plant
Salvia pratensis	• Magnet plant
Sedum sediforme	• High summer survival
Thymus vulgare	• High colonization capacity • Meliferous aromatic plant
Vella pseudocytisus	• High production of the flowers

ANNEX 3. Survival of species in among module after the summer.

Specie	Module 1	Module 2	Module 3	Module 4
Asphodelus albus	0	0	0	2
Colutea arborescens	5	1	0	0
Ephedra fragilis	2	3	0	3
Genista scorpius	1	2	0	2
Jasminum fruticans	5	4	0	1
Lavandula latifolia	6	5	1	2
Rosmarinus officinalis	5	3	3	1
Salvia pratensis	2	3	1	1
Sedum sediforme	0	4	3	3
Thymus vulgare	4	4	0	4
Vella pseudocytisus	6	4	4	2

To be kept and filled in at the end of your report

Project tags (select all appropriate):

This will be use to classify your project in the project archive (that is also available online)

Project focus:

☐**Beyond quarry borders**
☐**Biodiversity management**
☐Cooperation programmes
☐Connecting with local communities
☐Education and Raising awareness
☐Invasive species
☐Landscape management
☐**Pollination**
☐**Rehabilitation & habitat research**
☐**Scientific research**
☐Soil management
☐**Species research**
☐Student class project
☐Urban ecology
☐Water management

Flora:

☐Trees & shrubs
☐Ferns
☐**Flowering plants**
☐Fungi
☐Mosses and liverworts

Fauna:

☐Amphibians
☐Birds
☐**Insects**
☐Fish
☐Mammals
☐Reptiles
☐Other invertebrates
☐Other insects
☐Other species

Habitat:

☐**Artificial / cultivated land**
☐Cave
☐Coastal
☐**Grassland**
☐Human settlement
☐Open areas of rocky grounds
☐Recreational areas
☐Sandy and rocky habitat
☐Screes
☐Shrub & groves
☐**Soil**
☐Wander biotopes
☐Water bodies (flowing, standing)
☐Wetland
☐Woodland

Stakeholders:

☐**Authorities**
☐Local community
☐NGOs
☐Schools
☐**Universities**